

Appl. No : 09/413,177  
Amdt. dated : 04/02/04  
Reply to Office Action of 03/26/04

REMARKS/ARGUMENTS

Examiner Paul E. Brock II is thanked for thoroughly reviewing the subject application. Examiner is also thanked for the indication of allowing claims 3, 4 and 7 if these claims are rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Favorable reconsideration of this application in light of the following remarks is respectfully requested. All claims are believed to be in condition for allowance.

Claim rejections - 35 U.S.C. § 103

Reconsideration of the rejection of claims 1, 2, 5, 6, 15-17 and 22 under 35 U.S.C. 103(a) as being unpatentable over Lur et al. (U.S. Patent 5,413,962) in view of Staudinger et al. (U.S. Patent 5,481,131) is respectfully requested based on the following.

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Lur et al. (US Patent 5,413,962) provides for a multi-level electrode metal structure and the interconnecting inter-level metal studs used in the fabrication of VLSI circuits, in this respect therefore, Lur et al.:

- does not provide for creating a high quality inductor on the surface of a silicon semiconductor substrate as claimed in claims 1, 15-18, 20 of the instant invention
- does not provide for an dielectric of air that surrounds interconnect metal
- does not provide for a number of overlying air gaps that are interconnected as claimed in claims 1 and 3-5 of the instant invention
- Lur et al. does not provide for oxide fins (36, 38, Fig. 13 of the instant invention) underneath the metal inductor 44; the oxide fins of the instant invention provide support and stability for the overlying metal 44, simultaneously allowing horizontal air columns to exist underneath the inductor
- Lur et al. does not create an inductor (44, Fig. 13 of the instant invention) that overlies a upper layer of dielectric as claimed in claims 1 of the instant invention
- Lur et al. does not provide for openings (22, 24, 32 and 34, Fig. 13 of the instant invention) in layers of dielectric

through which nitride or any other disposable material can be removed as claimed in claims 3, 4, 5 of the instant invention

- Lur et al. does not provide for overlying layers of disposable material, such as nitride, interspersed with layers of dielectric as claimed in claims 1 and 3-5 of the instant invention
- the final construct that is provided by Lur et al. does not comprise horizontal air gaps (36, 38, Fig. 11 of the instant invention) between which horizontal layers of a dielectric are created, see Fig. 11 of the instant invention, and
- Lur et al. shows interconnect studs that connect to bit line and word lines of what appears to be a DRAM circuit configuration; gate electrodes are provided by Lur et al.; the instant invention is silent on this aspect of the Lur invention and is not limited to a DRAM device or the use of gate electrodes.

Regarding claims 1, 2 and 5 the following applies:

- the metal layer that is created by Lur et al., layer 26, Fig. 1, is connected to a source/drain region or to a gate electrode; the metal layer of the instant invention, layer 12, is not limited to being connected to a gate electrode

- the first layers of interconnect metal, layers 40, Fig. 1, that are created by Lur et al. connect to interconnect plugs 26; the instant invention does not create these first layers of interconnect metal
- Lur et al. deposits a number of thin envelop oxide layers such as layer 42, Fig. 1, layer 42, Fig. 2, layer 42, Fig. 4, layer 42, Fig. 6, layer 42, Fig. 8, layer 42, Fig. 9, layer 42, Fig. 10; all envelop layers have been referred to by the number "42" by Lur et al., the multiplicity of layers has been deposited for the figures that have been referenced; the instant invention does not make use of such thin layers of oxide for protective purposes of the interconnect metal
- applicant respectfully disagrees with Examiner regarding the statement that Lur et al. creates, Figs. 2-4, a structure for a first layer of cavities; Lur et al. does not make use of cavities but in contrast etches away the inter-level dielectric (col. 3, line 62) leaving an air dielectric 85, Fig. 11 of Lur et al.) between the electrode metal layers; an similar comment applies to Examiner's contention that Lur et al. creates a first and a second layer of cavities: the (only) cavity that is created by Lur et al. is cavity 85, shown in Fig. 11 where col. 3, lines 61 e.a.): "the inter-

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level dielectric is etched away". After the inter-level has been etched away, a (col. 3, lines 63 e.a.) "the surface of all electrode pattern metal and interlevel stud metal is covered with a coating of thin envelop oxide". Lur et al. provides an etch for the removal of the inter-level dielectric, which may be considered a standard procedure. Lur et al, therefore does not provide for the creation of overlying layers of disposable solid, nor for the creation of access holes through layers of dielectric nor for the removal of the disposable solid through these access holes, nor for creating (as the instant invention does) overlying and interconnected air cavities.

Staudinger et al. provides for an Integrated Circuit having passive circuit elements but at no time does Staudinger et al. provide for the essential aspects of the instant invention that have been summarized supra, that is:

- forming a structure for a first layer of cavities
- forming a structure for a second layer of cavities above and aligned with the structure for the first layer of cavities,
- creating a first and a second layer of cavities, and
- forming a metal inductor overlying the created cavities.

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Regarding claims 15-17, while many inductors are created having a spiral shape, not all inductors have a spiral shape. Since the inductor of the invention is created on the surface of a layer of dielectric, layer 42, Fig. 12, the inductor of the invention is not limited to a spiral shape but can also be circular or polygonal in shape. This is specified in claims 15-17.

Regarding claim 17, the inductor 44 of the invention is created having very low parasitic capacitance between the inductor 44, Fig. 13, and a metal layer 12, Fig. 13. For this reason the inductor 44 can be created having a high inductive value and can at the same time be used for high frequency applications.

In other words: by providing the claimed invention it is now possible in the context of the claimed invention to create a high (inductive and Q) value, high frequency inductor. The layer or layers of material underlying the inductor is key and of the essence to these performance characteristics of the inductor. It must therefore be recognized and specified that, if an inductor is created using the claimed invention, this inductor can be a high inductive value, high frequency performance inductor as

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claimed in claim 18. Without this claim it would not be clear just what could be accomplished using the claimed invention.

Regarding claim 22, Lur et al. provides for a layer 80, shown in the cross section of Fig. 11 of Lur et al., of passivation material, which is conventionally deposited over a created structure for the protection thereof.

This latter Lur et al. application bears no resemblance to the specification provided in claim 22 of the claimed invention, which specifies that the first layer and second layer of disposable solid are formed using nitride.

The Lur et al. application of nitride, as suggested for the layer 80 of passivation, is well known in the art and is as such not germane to the Lur et al. invention. The disposable solid of the claimed invention is used as part of a complex and complete processing sequence for the formation of air gaps within an integrated circuit structure. Two otherwise completely different processes cannot be equated for reasons of having one parameter in common, in this case the use of nitride, whereby however the nitride is used for entirely different purposes.

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The above arguments can be summarized by stating that it would not be obvious to combine the teachings of Lur et al. with those Staudiner, since there is no suggestion or motivation in the teachings of any of the patents of the present invention.

The Lur et al. and the Staudiner inventions do not provide for the creation of horizontal air gaps that are interspersed with layers of dielectric while further these inventions do not provide for a method of removal of a disposable solid, such as nitride, for the creation of the air gaps as claimed in claims 1, 2, 5, 6 and 15-17 of the claimed invention.

None of the applied or known references address the invention as shown in the amended claims in which air gaps are created between overlying layers of dielectric. The invention is believed to be patentable over the prior art cited, as it is respectfully suggested that the combination of these various references cannot be made without reference to Applicant's own invention. None of the applied references address the problem of creating a high inductive value, high frequency inductor overlying a layer of metal.



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Applicant has claimed his process in detail. The processes of Figs. 1-11, and the there-upon based and the there-from derived claims of the claimed invention, are believed to be both novel and patentable over these various references, because there is not sufficient basis for concluding that the combination of claimed elements would have been obvious to one skilled in the art. That is to say, there must be something in the prior art or line of reasoning to suggest that the combination of these various references is desirable. We believe that there is no such basis for the combination. We therefore respectfully request Examiner P. Brock II to reconsider his rejection in view of these arguments and the amendments to the Claims.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claims 1, 2, 5, 6, 15-17 under 35 U.S.C 103 as being unpatentable over Lur et al. (US Patent 5,413,962) in view of Staudinger et al. (US Patent 5,481,131), be withdrawn.

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Claim rejections - 35 U.S.C. § 103

Reconsideration of the rejection of claims 8-12 under 35 U.S.C 103 as being unpatentable over Lur et al. (US Patent 5,413,962) and Staudinger (US Patent 5,481,131) as applied to claim 1 above in view of Havemann et al. (US Patent 5,668,398) is respectfully requested based on the following.

The relative merits of Lur et al. and Staudinger with respect to claim 1 have been discussed above and are enclosed at this time by reference as being equally applicable to claims 8-12.

With respect to claim 8, this claim is a dependent claim to claim 1 and specifies that a polymer can be used for the first and second layers of disposable solid

While Havemann teaches the use of a disposable solid that comprises a polymer, the claimed invention and the Havemann invention have no commonality in either the way that air gaps are created, the design and the there-from following cross sections of the air gaps, the method in which the disposable solid is removed from the structure, and the like. The fact

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therefore that the disposable solid is commonly defined between Havemann and the claimed invention as being a polymer, while there is no further commonality between the claimed invention and the Havemann invention, cannot reasonably lead to the conclusion that one invention can be derived from the other invention, even by those who are skilled in the art.

It can in this respect and for purposes of comparison reasonably be asked whether two different cars, which have in common the use of a type of gas which is extracted from the gas tank, are by necessity the same cars or that the design and performance characteristics of one car is in any way related to the design and performance characteristics of the other car?

It is kindly suggested by Applicant that the same analogy between the Havemann and the claimed invention makes the use of a polymer by Havemann of no consequence in determining the uniqueness of the claimed invention.

With regard to claim 9, Havemann et al. teaches, col. 5, lines 49-67, that "the disposable solid layer 18 is removed through the porous dielectric layer 20 to form air gaps 22 as

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shown in Fig. 1E." This latter process is performed by "exposing the wafer to oxygen or oxygen plasma, the oxygen moves through the porous dielectric layer 20 to reach the disposable solid layer 18 and react with the solid layer 18 and convert it to a gas that moves back out of the porous dielectric 20."

Claim 9 specifies creating a first and a second layer of cavities is heating the substrate in oxygen, evaporating the disposable solid layer using O<sub>2</sub> plasma.

Claim 9 however is a dependent claim to claim 1, which specifies, among others: "forming a structure for a first layer of cavities over the thin layer of oxide and aligned with the metal layer, the forming a structure for a first layer of cavities comprising applying and patterning a first layer of disposable solid followed by applying and patterning a first layer of oxide, the patterning a first layer of oxide further comprising forming a first and a second opening through the first layer of oxide.

From the above quote it is clear that the invention directly, by creating openings through the first layer of oxide,

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provides a path for the removal of the disposable solid. Havemann does not provide for this but removes a solid through a more cumbersome process that has been detailed above and that, in view of the method applied by Havemann et al., does not lead to as direct and as thorough a removal of the solid as is provided by the instant invention, whereby the removable solid can be directly attacked by oxygen resulting in evaporating the disposable solid layer using O<sub>2</sub> plasma. This process is easier to apply, more effective and provides more dependable (better removal of the disposable solid) results in creation an air filled space in the surrounding layer.

With regards to claim 10, this claim teaches that creating a first and a second layer of cavities is introducing a solvent to the substrate, dissolving the polymer (that is used as a disposable solid).

Applicant has carefully reviewed the text cited by Examiner in Havemann et al. invention with respect to claim 10, that is col. 5, lines 49-67 and col. 6, lines 15-25, but is, contrary to Examiner's assertion, not able to locate any reference to the introduction of a solvent to the substrate.

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Regarding claim 11, Havemann in the description of Figs. 5A through 5D, to which Examiner refers, the description of which is provided by Havemann in Col. 6, lines 43-76 and col. 7, lines 1-11 and not, as asserted by Examiner, in col. 5, lines 49-67, does provide for cavities between patterned layers of metal. First, Fig. 5A of Havemann, patterned and overlying layers 16/28 of metal and second oxide are created over first oxide layer 14. A disposable solid 18, Fig. 5B, is deposited, a porous dielectric 20 is deposited over the disposable solid 18 after which the disposable solid 18 is evaporated through the porous layer 20 of dielectric, creating cavities 22, Fig. 5D, between adjacent of metal traces and there-over deposited layers 24 of second oxide.

Claim 11 of the instant invention specifies heating the substrate to evaporate the polymer, thereby creating a first and a second layer of cavities. These layers of cavities are clearly shown in the cross sections of Fig. 11, elements 36 and 38. These cavities are not between patterned layers of metal and oxide but are created as an interconnected structure 36/38 within the dielectric layer 30, the interconnects being openings 22 and 24. This interconnected structure cannot, in its creation or in its final cross section, be compared with the openings 22,

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Fig. 5D of Havemann for the reason that neither the creation nor the cross section have any commonality. The air gaps of the instant invention and the air gaps provided by Havemann et al. are created by removing a disposable solid, an opening is defined by the removable solid after which the removable is removed. Not in common between Havemann et al. and the instant invention are, among others, the process of the creation of the patterned layers of disposable solid, the cross sections of the created layers of disposable solid, the manner in which the disposable solid is removed, the layers that are adjacent to the created layers of disposable solid and the final structure, of which the air cavities form a part.

Havemann et al. does not, contrary to Examiner's assertion, provide for a first and a second layer of cavities, Havemann creates one layer of cavities surrounded by metal interconnects and overlying patterned layers of oxide.

Regarding claim 12, which specifies creating a first and a second layer of cavities by applying a vacuum to the substrate, dissolving the polymer, the invention provided by Havemann does not provided for this method in essence because Havemann does not provide openings 32/34 and 22/24, shown in Fig. 11 of the

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instant invention, through which the disposable solid is directly accessible and through which the disposable solid can therefore directly be removed. Havemann et al. would, in applying as vacuum to the substrate, most likely destroy the porous layer 20, Fig. 5C, overlying the created air gaps.

While applicant acknowledges the teachings of Lur, Staudinger and Havermann et al. as cited by the Examiner, and although applicant does not necessarily agree that the Examiner's arguments show sufficient and proper basis for suggestion or motivation to modify or combine Lur, Staudinger and Havermann et al., applicant nonetheless also asserts that there is absent within the portions of Lur, Staudinger and Havermann et al. or any combination thereof, as cited by the Examiner, an express or inherent teaching of each and every limitation within applicant's invention as taught and claimed within claims 8-12 of the instant invention.

Claims 8-12 are dependent claims to claim 1, neither Lur or Staudinger nor Havermann et al. nor any combination thereof provide for the aspects of the instant invention that are specified in independent claim 1 of the invention on which claims 8-12 are based.



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Specifically provided by the instant invention, aspects that are not provided by Lur nor Staudinger nor Havermann et al. or any combination thereof, are:

- forming a structure for a first layer of cavities over a thin layer of oxide and aligned with a metal layer, by applying and patterning a first layer of disposable solid followed by applying and patterning a first layer of oxide, thereby forming a first and a second opening through the first layer of oxide
- forming a structure for a second layer of cavities above and aligned with the structure for the first layer of cavities by applying and patterning a second layer of disposable solid followed by applying and patterning a second layer of oxide thereby forming a first and a second opening through the second layer of oxide
- creating the first and the second layer of cavities
- performing an oxide deposition over the second layer of cavities, creating a thin layer of oxide, and
- forming a metal inductor on the thin layer of oxide.

To combine the teachings of Lur and Staudinger and Havermann et al. is not obvious, since there is no suggestion or

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motivation in the teachings of any of these patents of the

present invention. The instant invention specifically provides a method of forming air gaps within an integrated circuit structure and of forming a metal inductor on an upper thin layer of oxide. In the context of the instant invention, and not either supported by or inferred by or referred to by Lur and Staudinger and Havermann et al. singly or in combination thereof, provides a first and second layer of cavities, the cavities interconnected with openings, the second layer of cavities exposed through openings for easy and complete removal of a created patterned layer of a disposable solid, over the surface of a substrate.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claims 8-12 under 35 U.S.C 103, be withdrawn.

Claim rejections - 35 U.S.C. § 103

Reconsideration of the rejection of claims 13 and 18 under 35 U.S.C 103 as being unpatentable over Lur et al. (US Patent 5,413,962) and Staudinger as applied to claim 1 above in view of Abidi et al. (US Patent 5,481,131) is respectfully requested based on the following.

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The relative merits of Lur et al. (US Patent 5,413,962) and Staudinger (US Patent 5,481,131) relating to claim 1 have been discussed above and are enclosed at this time by reference as being equally applicable to claims 13 and 18.

Regarding claim 13, it is clear that an insulation layer, as specified by Abidi et al., can be used for multiple applications. In the case of the instant invention, the insulation layer is specified and provided in order to provide a more rugged construction that is protected from environmental impact during subsequent processing cycles. Without this protective layer the inductor of the invention would be exposed and unprotected, resulting in a device that is prone to environmental damage.

Abidi et al. creates an inductor over a pit in a substrate and essentially shows the inductor as having a spiral shape. Other shapes are highlighted by Abidi et al., which however does not provide any commonality between Abidi et al. and the instant invention.

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The essence of the instant invention is the creation of air gaps interspersed with layers of dielectric, Abidi does not address these aspects of the instant invention. It must again be pointed out that, since the inductor of the instant invention is created overlying the surface of a layer of dielectric, this inductor is not in any way limited to the shape in which this inductor can be created. For this reason the various shapes in which an inductor can be created must be specified in order to avoid incompleteness of the specification or the claims.

Regarding claim 18, the inductor of the invention is created having very low parasitic capacitance between the inductor 44, Fig. 13, and a metal layer 12, Fig. 13. For this reason the inductor can be created having a high inductive value and can at the same time be used for high frequency applications. In other words: by providing the invention it is now possible in the context of the instant invention to create a high value, high frequency inductor. The layer of material underlying the inductor is key and of the essence to these performance characteristics of the inductor. It must therefore be recognized and specified that, if an inductor is created using the instant invention, this inductor can be a high

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inductive value, high frequency performance inductor as claimed in claim 18. Without this claim it would not be clear just what could be accomplished using the invention.

The above arguments can be summarized by stating that it would not be obvious to combine the teachings of Lur et al. with those of Staudinger and Abili et al., since there is no suggestion or motivation in the teachings of any of the patents of the present invention.

None of these inventions provide for the creation of horizontal air gaps that are interspersed with layers of dielectric while further none of these inventions provide for a method of removal of a disposable solid, such as nitride, for the creation of the air gaps as claimed in the claims of the instant invention. None of the applied or known references address the invention as shown in the amended claims in which air gaps are created between overlying layers of dielectric.

The invention is believed to be patentable over the prior art cited, as it is respectfully suggested that the combination

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of these various references cannot be made without reference to Applicant's own invention.

None of the applied references address the problem of creating a high inductive value, high frequency inductor overlying a layer of metal. Applicant has claimed his process in detail. The processes of Figs. 1-11 are believed to be both novel and patentable over these various references, because there is not sufficient basis for concluding that the combination of claimed elements would have been obvious to one skilled in the art.

That is to say, there must be something in the prior art or line of reasoning to suggest that the combination of these various references is desirable. We believe that there is no such basis for the combination. We therefore respectfully request Examiner P. Brock II to reconsider his rejection in view of these arguments and the amendments to the Claims.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claims 13 and 18 under 35 U.S.C 103, be withdrawn.

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Claim rejections - 35 U.S.C. § 103

Reconsideration of the rejection of claim 14 under 35 U.S.C 103 as being unpatentable over Lur et al. (US Patent 5,413,962) and Staudinger as applied to claim 1 above in further in view of One of ordinary skill in the art.

The relative merits of Lur et al. (US Patent 5,413,962) and Staudinger (US Patent 5,481,131) relating to claim 1 have been discussed above and are enclosed at this time by reference as being equally applicable to claim 14.

Claim 14 specifies that the partially fabricated integrated circuit structure comprising transistors being bipolar or CMOS devices interconnected to form an RF amplifier.

This aspect of the instant invention is not implied without the specific identification there-of as provided in claim 14. It has been stated previously that, by providing the invention it is now possible in the context of the instant invention to create a high value, high frequency inductor.

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Such an inductor, having high inductive and high Q values is most suited for application as a high frequency inductor for high-end performance devices. Such devices however can be created for a number of different applications, one of the preferred applications of the invention is that the inductor, created by the invention, as applied in combination with CMOS devices whereby these CMOS devices more specifically are interconnected to form an RF amplifier.

Claim 14, which is a dependent claim to claim 1, therefore limits the invention to a specific application, which represents an important market segment of semiconductor devices and which therefore requires to be specifically identified.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claim 14 under 35 U.S.C 103, be withdrawn.

#### Other Considerations

No new independent or dependent claims have been written as a result of this office action, no new charges are therefore incurred due to this office action.



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It is requested that, should Examiner not find the claims to be allowable, to call the undersigned Attorney at the Examiner's convenience at 845-452-5863 in order to overcome any problems preventing allowance of the claims.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'S. B. Ackerman', with a large, stylized loop at the end.

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